The Economic Impact of Broadband Deployment in Kentucky

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Significant resources are being invested by government and the private sector in broadband infrastructure to increase broadband deployment and use. With a unique dataset of broadband availability (sorted by county), the authors assess whether broadband infrastructure has affected the industrial competitiveness of Kentucky counties. Their results suggest that broadband availability increases employment growth in some industries but not others. (JEL H54, R11)

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As the "knowledge economy" continues to transform our society, broadband internet access is an essential component of infrastructure for economic development. Broadband deployment and use is expected to offer benefits to businesses and consumers as well as the public sector. Potential benefits of broadband usage to businesses include productivity gains through e-commerce, integrated supply chains, improved management (Williamson et al., 2006), and increased productivity through telecommuting. There are substantial foreseeable benefits of residential broadband use, including improved efficiency of retailing, reductions in commuting, increased variety of home entertainment, greater availability of health care, and improved access to educational opportunities. In addition, broadband facilitates the delivery of e-government services and applications, bringing the potential to significantly enhance government communication with its constituents. Similarly, broadband enables online community applications, which provide additional opportunities for individuals to contribute to society, especially the disabled. Crandall and Jackson (2001) projected that these benefits would lead to a $500 billion increase in U.S. gross domestic product by 2006.

In response to these perceived benefits of broadband, Kentucky embarked on "Prescription for Innovation"—a unique broadband deployment and adoption plan that leverages state, federal, and private investment to ensure statewide broadband availability and significantly improve technology adoption. ConnectKentucky, a public-private partnership, has the charge of realizing the four strategic goals of Prescription for Innovation:

- full broadband deployment by the end of 2007;
- increased use of computers and the Internet;
- the creation of a meaningful online presence for every local community;
- the development of e-community leadership teams to form business plans and identify applications for business, local government, education, health care, libraries, agriculture, tourism, and local nongovernmental organizations.

To date, ConnectKentucky has achieved and

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exceeded expectations by realizing a deployment rate of 94 percent of Kentucky households, with deployment planned to cover the remaining 6 percent by the end of 2007; a 73 percent increase in the use of broadband in the home since 2004; and a 20 percent increase in household computer ownership since 2004.

ConnectKentucky has become a model for broadband deployment and adoption for other states throughout the nation because of these successes; moreover, a national nonprofit organization, Connected Nation, Inc., has been created to replicate its model in other states.

Empirical evidence ex post of broadband investments by governments and the private sector is sparse. Quantifying many of the benefits described above requires extensive data collection, which is costly and time consuming. Therefore, the existing evidence has focused on economic impacts, measured in terms of employment growth or efficiency gains from broadband adoption. For example, Lehr et al. (2005) estimate the impacts of broadband availability on a number of economic indicators such as employment growth, wages, proportion of establishments in information technology (IT), and rental rates between 1998 and 2002. The study concludes that the communities in which broadband became available by 1999 experienced more rapid growth in employment, the number of businesses overall, and the number of businesses in IT-intensive sectors. Lehr et al. also observed higher market rates for rental housing in the communities with broadband availability. In another study, Crandall, Lehr, and Litan (2007), finds similar results, though the scope of analysis is limited to only employment and output.

The present study focuses exclusively on the economic impact that broadband deployment has had in Kentucky's local communities. Although most of the early studies relied upon projections of forward linkages, this study will look at observed changes in economic activity related to broadband deployment, as did Lehr et al. (2005) and Crandall, Lehr, and Litan (2007). A major difference between the previous studies and the present one is in our measure of broadband availability. The previous studies use data from Federal Communication Commission (FCC) Form 477 to measure broadband data availability. In the case of Lehr et al. (2005), Form 477 data identifies the number of broadband providers with at least one subscriber in each zip code. Crandall, Lehr, and Litan (2007) use the state-level Form 477 data, which provides the number of lines available (i.e., the number of subscribers) in each state. Our measure utilizes county-level data aggregated from ConnectKentucky's GIS database of broadband service as measured at the point of service. That is, ConnectKentucky uses proprietary infrastructure data from broadband providers to determine in which geographic areas broadband service is offered. Measuring broadband availability this way is superior to the previous measures because it provides a more accurate assessment of where broadband is available; the zip code data exaggerates broadband availability,[1] while the state-level data is too geographically aggregated to identify variances in broadband coverage.

Following in the spirit of Lehr et al. (2005), this study uses an economic growth framework to determine the impact of broadband deployment on economic activity in Kentucky's counties. The next section describes our data and methodology in more detail and is followed by our estimation results. We conclude with a discussion of extensions and policy implications of this work.

DATA AND METHODOLOGY

Identifying the impact of infrastructure poses several challenges that make the analysis different from that for other economic impacts. First, a typical economic impact analysis identifies the employment creation and related economic benefits associated with the expansion in the local economy. Infrastructure itself does not create sustained employment, only temporary employment associated with construction or maintenance. Second, standard economic impact analyses are based on backward linkages. In a traditional impact analysis, accounting for the backward linkages among firms

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[1] The U.S. Government Accountability Office reported that the FCC Form 477 zip code data overstates broadband availability because an entire zip code is reported as having broadband if at least one subscriber is located there; this is a poor measure of availability, particularly in rural areas where zip codes tend to be large geographic areas.

is what allows researchers to identify how growth in one industry will lead to growth in others. However, it is often difficult to predict how specific types of infrastructure will be utilized by industries, particularly previously unavailable infrastructure like broadband. Since there is no prior history of the use of broadband in a locale, there is no way to predict which firms will or will not utilize the infrastructure and how use of the infrastructure will affect the firms' production processes. Additionally, the presence of the new infrastructure may also make the region attractive to new firms that will relocate to take advantage of it. Given these difficulties, economists often estimate the economic impacts of infrastructure using a modified growth model. (See Rupasinga, Goetz, and Freshwater, 2000, and Lehr et al., 2005, for additional applications of this model.)

The growth model is a methodology to predict a region's growth over time. Simply stated, this model predicts the economic growth of a region during one period based upon the level of economic activity of some previous period plus any compounded growth that would be expected to occur between the two periods. Mathematically, this process can be expressed as

$$Y_t = AY_{t-i}^{\alpha}e^{ri},$$

where Y represents the economic level at time t, A is a constant, α is a scaling parameter, and e^{ri} is the formula for compounded growth at rate r for i periods. The critical element of this approach is determining the right expected growth rate, r, between the two periods. Because of the importance of this step, the growth rate, r, is often determined statistically using multivariate regression analysis. By transforming this growth equation using natural logarithms, assuming that A and α equal 1 (which are standard assumptions when empirically testing growth models), and defining time periods in such a way as to make $i = 1$, equation (1) is derived:

(1) $$\ln\left(Y_t/Y_{t-1}\right) = r = r^* + X\beta + \varepsilon.$$

This equation simply states that the economic growth rate is a function of the optimal growth rate, r^* (which is constant), some explanatory variables (X), and an error term, ε (which has a log-normal distribution). It is reasonable to assume that the observed rate of economic growth will differ from the optimum growth rate in any given period simply because of unanticipated shocks to the economy. This is the same theoretical model used in Lehr et al. (2005). If one takes Y to represent industrial output, instead of aggregate economic activity, this framework can also be used to analyze the effect of broadband infrastructure on specific industries, where the change in industrial output is estimated by various input factors and a random error term.

Empirically, measuring growth and identifying explanatory variables poses some challenges. Because output is not measured at the local level (like gross domestic or state product), researchers often use employment, wages, or number of establishments data as a proxy for the size of the local economy. Given our desire to look at total economic impacts and industrial impacts from broadband, we use the U.S. Census Bureau's county business patterns data series for 2003, 2004, and 2005 as our economic data because it provides both total and sectoral employment at the two-digit North American Industrial Classification System (NAICS) level. This dataset contains private, non-agriculture production employment data measured as of the week of March 12 annually. Using this data, we compute the employment growth rates of the periods 2003-04 and 2004-05 for each of the two-digit NAICS codes. A combination of zero employment levels in rural counties and suppressed data due to Census disclosure rules led to missing values in the data and reduced the number of observations available for analysis in some industries. Table 1 provides summary statistics and the number of observations for the employment growth rates.

Additional data concerns stemmed from the very diverse nature of counties in Kentucky. For example, in 2004, total employment across counties ranged from 131 employees to over 400,000 employees; the average county employment was 12,681, while the median county employment was only 3,554. This wide distribution of values becomes even more of a concern because our analysis uses growth rates, such that a small increase in employment, say 25 employees, could

Table 1A

Summary Statistics

Dependent variable	Employment growth (2004-05)	N	Minimum	Maximum	Mean	Standard deviation
emp00_45	Total employment growth	120	–0.27	0.17	0.01	0.05
emp11_45	Employment growth in forestry, fishing, and hunting	26	–1.00	1.33	–0.16	0.69
emp21_45	Employment growth in mining	34	–1.00	1.48	0.00	0.57
emp22_45	Employment growth in utilities	21	–1.00	0.33	–0.15	0.37
emp23_45	Employment growth in construction	112	–1.00	0.72	–0.03	0.37
emp31_33_45	Employment growth in manufacturing	103	–1.00	1.59	–0.02	0.26
emp42_45	Employment growth in wholesale trade	100	–1.00	2.67	–0.08	0.46
emp44_45_45	Employment growth in retail trade	119	–0.22	0.27	0.01	0.08
emp48_49_45	Employment growth in transportation and warehousing	94	–1.00	3.90	–0.06	0.65
emp51_45	Employment growth in information	88	–1.00	0.92	–0.44	0.52
emp52_45	Employment growth in finance and insurance	112	–1.00	1.22	0.02	0.32
emp53_45	Employment growth in real estate and rental and leasing	97	–1.00	1.38	–0.10	0.45
emp54_45	Employment growth in professional, scientific, and technical services	111	–1.00	0.73	–0.24	0.47
emp55_45	Employment growth in management of companies and enterprises	30	–1.00	1.57	0.04	0.54
emp56_45	Employment growth in administrative and support and waste management and remediation services	87	–1.00	2.68	0.01	0.73
emp61_45	Employment growth in educational services	39	–1.00	0.66	–0.29	0.53
emp62_45	Employment growth in health care and social assistance	118	–1.00	0.85	0.01	0.15
emp71_45	Employment growth in arts, entertainment, and recreation	62	–1.00	1.08	–0.17	0.44
emp72_45	Employment growth in accommodation and food services	111	–1.00	1.28	–0.03	0.34
emp81_45	Employment growth in other services	116	–1.00	0.58	–0.09	0.25
emp99_45	Employment growth in unclassified	22	–1.00	2.00	–0.64	0.82

Table 1B

Independent variable	Employment growth (2003-04)	N	Minimum	Maximum	Mean	Standard deviation
emp00_34	Total employment growth	120	–0.23	0.40	0.01	0.07
emp11_34	Employment growth in forestry, fishing, and hunting	120	–1.00	1.50	–0.19	0.21
emp21_34	Employment growth in mining	120	–1.00	1.14	–0.04	0.25
emp22_34	Employment growth in utilities	120	–1.00	0.03	–0.15	0.12
emp23_34	Employment growth in construction	120	–1.00	1.03	0.03	0.29
emp31_33_34	Employment growth in manufacturing	120	–1.00	1.42	0.01	0.21
emp42_34	Employment growth in wholesale trade	120	–1.00	1.00	–0.03	0.27
emp44_45_34	Employment growth in retail trade	120	–0.35	1.06	0.01	0.13
emp48_49_34	Employment growth in transportation and warehousing	120	–1.00	1.00	–0.03	0.37
emp51_34	Employment growth in information	120	–1.00	2.15	–0.08	0.31
emp52_34	Employment growth in finance and insurance	120	–1.00	1.05	0.00	0.20
emp53_34	Employment growth in real estate and rental and leasing	120	–1.00	2.90	0.01	0.45
emp54_34	Employment growth in professional, scientific, and technical services	120	–1.00	5.46	0.04	0.57
emp55_34	Employment growth in management of companies and enterprises	120	–1.00	0.94	0.00	0.16
emp56_34	Employment growth in administrative and support and waste management and remediation services	120	–1.00	4.25	–0.04	0.50
emp61_34	Employment growth in educational services	120	–1.00	0.58	–0.03	0.18
emp62_34	Employment growth in health care and social sssistance	120	–0.51	0.56	0.00	0.12
emp71_34	Employment growth in arts, entertainment, and recreation	120	–1.00	0.67	–0.08	0.31
emp72_34	Employment growth in accommodation and food services	120	–1.00	0.58	0.01	0.21
emp81_34	Employment growth in other services	120	–1.00	0.46	–0.02	0.21
emp99_34	Employment growth in unclassified	120	–1.00	3.67	–0.28	0.45
	Other					
sat104	Percent of county area with broadband service as of January 1, 2004	120	0.01	1.00	0.50	0.30
sat1042	sat104 squared	120	0.00	1.00	0.34	0.35
hwyaccess	Miles of limited-access roads	120	0.00	303.50	26.06	39.97
bached00	Percent of persons 25+ with at least a bachelors degree	120	0.05	0.36	0.12	0.06
unemp03	Unemployment rate, 2003	120	0.04	0.12	0.07	0.02
rural	Rural dummy variable (1 = rural county)	120	0.00	1.00	0.58	0.50

lead to a 19 percent increase in employment in the county with the least employment or a 0.00006 percent increase in the county with the highest employment. To ensure that no one observation heavily influenced the values in our results, we identified influential observations using "studentized" residuals in the analysis of each industry. Influential observations were those for which the residual value exceeded 2 in absolute value; these counties were excluded from the analysis of that industry to ensure that the results were representative of counties across Kentucky.[2] Several industries showed signs of heteroskedasticity, according to White's general test. Generalized least-squares procedures were used to correct for the heteroskedastic error term for the following industries: wholesale trade; transportation and warehousing; information; real estate and rental and leasing; and professional, scientific, and technical services.[3]

Data for our independent variables came from several sources. To measure broadband availability, we computed the area of a county for which broadband service is available using ConnectKentucky's GIS inventory of Kentucky's broadband deployment and service availability. The GIS inventory provides a comprehensive view of broadband technologies, representing digital subscriber lines (DSL), cable modem service, and fixed wireless networks, measured at the point of service availability (i.e., at the location of infrastructure placement). Coverage areas were aggregated to the county level by Census block groups, and then the ratio of the coverage area to total area of the county was computed. This saturation rate was our measure of broadband infrastructure as of January 2004.

Early studies of the economic impacts of broadband, based on forward-looking models, suggest a range of potential benefits of broadband to businesses. This includes reduced costs and increased productivity of the workforce as well as prospects of expansion and growth, as businesses will no longer be constrained in their local market. Because there is no history of the use of broadband in a locale, the overall expected impact of broadband on employment growth can be twofold. On one hand, broadband can lead to job losses, but higher wages, through increased labor productivity. On the other hand, it can lead to job creation as a result of longer-term productivity increases and/or as businesses expand their markets and venture into regional and international markets. The overall effect will depend on the type of industry as well as the length and scope of broadband adoption by a particular business.

The saturation rate squared is also included to study the returns to scale of broadband deployment. For instance, diminishing returns, captured by a negative coefficient of saturation squared, would indicate that, as broadband deployment nears its maximum (100 percent coverage of area), its marginal effect on employment growth diminishes. In other words, if the county is nearing 100 percent served, adding an additional unit of broadband infrastructure to unserved portions of that county would provide smaller additional benefit in terms of job growth. This phenomenon could be related to the increasing necessity of broadband within the economy; as broadband service within a county becomes ubiquitous, it becomes expected infrastructure, and thus other economic variables become those factors that influence variations in job growth. It is worth noting, however, that this study does not account for multiple layers of broadband service; that is, we have focused solely on job growth as it relates to broadband deployment at a given point in time. This paper does not consider the possibility that competition among broadband service providers may also affect job growth, and consideration of this idea is left for future research.

Our control variables were generated from standard, secondary sources. Educational attainment, measured as the percent of the population 25 years and older with at least a college degree in 2000, was provided by the Kentucky State Data Center. Educational attainment is a proxy for human capital stock; one expects that higher educational attainment within a county will lead to more economic activity due to the availability of more productive human capital. The level of nontechnological infrastructure was measured as the number of miles of limited-access highway

[2] Excluding outliers explains why the number of observations reported in Table 1 might differ from the number of observations (n) reported in the results tables.

[3] Because ordinary least-squares estimators are still unbiased under heteroskedasticity, generalized least-squares techniques correct the standard errors of the parameter estimates, but they do not affect the value of the estimates.

miles; these data were computed using the major-roads shapefile from the Kentucky Transportation Cabinet, available through the Kentucky Geography Network. From the attribute table, we summed the length of interstates and parkways in miles, reported as DMI_LEN_MI, for DRAWCODE value 5 (interstates and parkways) in each county, denoted by CO_NUMBER. One would also expect a positive relationship between highway access and economic activity, since more accessibility should reduce transportation and distribution costs to firms. Other control variables include a rural region dummy variable to control for differences between urban and rural places (such as population density); ConnectKentucky has a four- category classification system (1 = rural, 2 = small metropolitan, 3 = suburban, and 4 = metropolitan)[4] that was adopted for this project. This variable takes a value of 1 for counties designated rural, and 0 otherwise. The county unemployment rate in 2003, as reported in the Local Area Unemployment Statistics series from the U.S. Bureau of Labor Statistics, was included as a proxy for the amount of available labor in the county. If this variable were positively correlated with employment growth, it suggests that the industry is labor intensive so that more available labor (typically less skilled labor) leads to more employment. If this variable is negatively correlated with employment growth, it suggests that the industry is not labor intensive and/or it is able to recruit its labor from outside of the county. Lastly, a lagged version of the dependent variable was included to capture any other unique characteristics about the county and/or the industry within the county.

To determine the impact that broadband infrastructure has had on Kentucky's local economies, we used multivariate regression. In our analysis, we regress the employment growth for 2004-05 for each of the 21 two-digit industrial codes as a function of broadband saturation, saturation squared, highway access, percentage of the population over 25 with a college degree, employment growth between 2003 and 2004, the unemployment rate in 2003, and the rural dummy variable.

[4] ConnectKentucky developed this system to more accurately reflect the regional differences across Kentucky that are not evident when one uses the U.S. Department of Agriculture's rural-urban continuum.

RESULTS

This section presents regression analysis of the impact of broadband deployment on employment growth in 20 industrial sectors (using two-digit NAICS codes and excluding public administration) and total employment growth in Kentucky. The results are presented in Tables 2 through 22.

To thoroughly understand the role of broadband in economic development, we conducted our analysis using a series of models, similar to the structure used by Lehr et al. (2005). That is to say, we present the results of four models for each industry to see how the influence of saturation and its square changes as additional controls are introduced into the model. Our first model, then, contains only saturation and saturation squared as explanatory variables. Our second model adds the lagged employment-growth variable. The third model contains all control variables except saturation and saturation squared. The final model, the most complex, contains all of our independent variables. We also report *F*-statistics to determine the overall significance of the models.

The results of greatest interest relate to the significance and magnitude of the broadband variables. The broadband deployment variable has a positive and significant impact on total employment (Table 2) as well as employment growth in the following industries: mining (Table 4), construction (Table 6), information (Table 11), and administrative, support, and waste management and remediation services (Table 16). The square of broadband deployment is negative and significant in all of the above industries, suggesting diminishing returns, as explained above. Broadband's contribution to total employment growth ranges from 0.14 to 5.32 percent.[5]

[5] The ranges presented are calculated across the various models for each industry and across the range of saturation values. The lower bound of the range corresponds to the parameter estimates of the simplest model, for which the broadband parameter(s) are significant, multiplied by the minimum amount of broadband saturation of the observations used for that industry's regression. The upper bound of the range corresponds to the parameter estimates of the most complex model, for which the broadband parameter(s) are significant, multiplied by the mean amount of broadband saturation of the observations used for that industry's regression. Because of the diminishing returns to scale, the maximum saturation rate yields lower employment growth than the mean.

Table 2

Regression Results for Total Employment

	Model 1	Model 2	Model 3	Model 4
Intercept	–0.0163 (–1.339)	–0.0161 (–1.322)	0.0202 (0.787)	–0.0091 (–0.335)
sat104	0.1503*** (2.893)	0.1499*** (2.878)		0.1727*** (3.042)
sat1042	–0.1162*** (–2.574)	–0.1158*** (–2.559)		–0.1340*** (–2.738)
emp00_34		–0.0329 (–0.603)	–0.0410 (–0.702)	–0.0373 (–0.662)
hwyaccess			0.000071 (0.662)	0.000055 (0.529)
bached00			–0.0047 (–0.053)	–0.0694 (–0.781)
unemp03			–0.0463 (–0.163)	–0.1353 (–0.484)
rural			0.0024 (0.256)	0.0069 (0.740)
R^2	0.079	0.082	0.008	0.096
Adjusted R^2	0.062	0.057	–0.038	0.036
F-statistic	4.76***	3.28**	0.17	1.61
n	114	114	114	114

NOTE: Numbers in parentheses are *t*-statistics; */**/*** indicates significance at the 10/5/1 percent confidence levels.

Table 3

Regression Results for Forestry, Fishing, and Hunting

	Model 1	Model 2	Model 3	Model 4
Intercept	–0.2613	–0.2414	0.9713	0.6373
	(–0.574)	(–0.517)	(1.004)	(0.543)
sat104	1.2113	1.1012		0.2237
	(0.589)	(0.520)		(0.097)
sat1042	–1.4430	–1.3875		–0.4898
	(–0.792)	(–0.745)		(–0.241)
emp11_34		–0.1636	–0.2846	–0.3323
		(–0.387)	(–0.681)	(–0.749)
hwyaccess			–0.003825	–0.003697
			(–1.572)	(–1.419)
bached00			–0.0666	1.0385
			(–0.023)	(0.295)
unemp03			–12.1320	–9.5106
			(–1.252)	(–0.832)
rural			–0.2611	–0.1630
			(–0.699)	(–0.373)
R^2	0.057	0.063	0.252	0.267
Adjusted R^2	–0.025	–0.065	0.064	–0.018
F-statistic	0.69	0.49	1.34	0.94
n	26	26	26	26

NOTE: Numbers in parentheses are *t*-statistics; */**/*** indicates significance at the 10/5/1 percent confidence levels.

Table 4

Regression Results for Mining

	Model 1	Model 2	Model 3	Model 4
Intercept	–1.1524***	–1.1251**	1.4845**	0.2549
	(–2.704)	(–2.563)	(2.434)	(0.348)
sat104	4.2753***	4.1584**		4.0498**
	(2.744)	(2.579)		(2.603)
sat1042	–3.2672**	–3.1826**		–3.2633**
	(–2.595)	(–2.451)		(–2.599)
emp21_34		0.0885	0.4037	0.3089
		(0.376)	(1.689)	(1.378)
hwyaccess			0.001596	0.002309
			(1.063)	(1.614)
bached00			–1.8336	–1.8579
			(–1.187)	(–1.264)
unemp03			–18.6839***	–17.1996***
			(–2.785)	(–2.787)
rural			0.1482	0.2808
			(0.733)	(1.430)
R^2	0.217	0.221	0.313	0.471
Adjusted R^2	0.161	0.134	0.176	0.310
F-statistic	3.88**	2.55*	2.28*	2.92**
n	31	31	31	31

NOTE: Numbers in parentheses are *t*-statistics; */**/*** indicates significance at the 10/5/1 percent confidence levels.

Table 5

Regression Results for Utilities

	Model 1	Model 2	Model 3	Model 4
Intercept	0.2007	0.1284	0.0478	1.4081*
	(0.513)	(0.334)	(0.068)	(1.832)
sat104	–1.5917	–1.0432		–4.3522***
	(–1.066)	(–0.692)		(–3.083)
sat1042	1.4710	1.1594		4.1867***
	(1.115)	(0.889)		(3.113)
emp22_34		1.7583	2.2656	1.2979
		(1.389)	(1.574)	(0.972)
hwyaccess			–0.000802	–0.003194*
			(–0.569)	(–1.901)
bached00			1.4976	–0.0028
			(0.711)	(–0.002)
unemp03			–2.3573	–2.3171
			(–0.277)	(–0.312)
rural			–0.2484	–0.7213**
			(–0.988)	(–2.770)
R^2	0.068	0.168	0.408	0.675
Adjusted R^2	–0.041	0.013	0.197	0.485
F-statistic	0.62	1.08	1.93	3.56**
n	20	20	20	20

NOTE: Numbers in parentheses are *t*-statistics; */**/*** indicates significance at the 10/5/1 percent confidence levels.

Table 6

Regression Results for Construction

	Model 1	Model 2	Model 3	Model 4
Intercept	–0.0449	–0.0114	0.4658***	0.3001**
	(–0.621)	(–0.148)	(3.310)	(1.989)
sat104	0.6704**	0.5592*		0.7974**
	(2.198)	(1.766)		(2.447)
sat1042	–0.6827**	–0.5877**		–0.7267**
	(–2.575)	(–2.139)		(–2.606)
emp23_34		–0.1343	–0.1758*	–0.1089
		(–1.266)	(–1.711)	(–1.049)
hwyaccess			0.000146	0.000167
			(0.274)	(0.319)
bached00			–1.2414***	–1.3336***
			(–2.730)	(–2.820)
unemp03			–3.4686**	–3.3877**
			(–2.190)	(–2.121)
rural			–0.0144	0.0061
			(–0.302)	(0.130)
R^2	0.081	0.096	0.118	0.180
Adjusted R^2	0.062	0.068	0.071	0.118
F-statistic	4.28**	3.40**	2.51**	2.88***
n	100	100	100	100

NOTE: Numbers in parentheses are *t*-statistics; */**/*** indicates significance at the 10/5/1 percent confidence levels.

Table 7

Regression Results for Manufacturing

	Model 1	Model 2	Model 3	Model 4
Intercept	0.0098	0.0181	–0.0100	–0.0047
	(0.238)	(0.430)	(–0.118)	(–0.052)
sat104	–0.0380	–0.0622		–0.0397
	(–0.214)	(–0.347)		(–0.207)
sat1042	0.0226	0.0375		0.0269
	(0.144)	(0.238)		(0.162)
emp31_33_34		–0.0605	–0.0546	–0.0577
		(–1.022)	(–0.926)	(–0.949)
hwyaccess			0.000203	0.000191
			(–0.639)	(–0.584)
bached00			–0.0821	–0.0611
			(–0.305)	(–0.216)
unemp03			0.4527	0.4918
			(0.475)	(0.505)
rural			–0.0094	–0.0097
			(–0.329)	(–0.331)
R^2	0.001	0.012	0.023	0.023
Adjusted R^2	–0.020	–0.019	–0.030	–0.052
F-statistic	0.06	0.39	0.43	0.31
n	99	99	99	99

NOTE: Numbers in parentheses are *t*-statistics; */**/*** indicates significance at the 10/5/1 percent confidence levels.

Table 8

Regression Results for Wholesale Trade

	Model 1	Model 2	Model 3	Model 4
Intercept	–0.1101	–0.0762	0.2908	0.3092
	(–0.925)	(–0.641)	(1.261)	(1.260)
sat104	0.3479	0.2222		–0.3899
	(0.683)	(0.438)		(–0.710)
sat1042	–0.4463	–0.3627		0.0898
	(–0.993)	(–0.814)		(0.180)
emp42_34		0.3139*	0.3328**	0.4010*
		(1.885)	(2.149)	(1.960)
hwyaccess			0.001039	0.001308
			(1.242)	(1.140)
bached00			0.2426	0.7408
			(0.325)	(1.240)
unemp03			–6.2595**	–5.0516*
			(–2.530)	(–1.820)
rural			–0.0094	–0.0219
			(–0.116)	(–0.290)
R^2	0.027	0.063	0.190	0.244
Adjusted R^2	0.006	0.032	0.144	0.183
F-statistic	1.27	2.05	4.17***	4.02***
n	95	95	95	95

NOTE: Numbers in parentheses are *t*-statistics; */**/*** indicates significance at the 10/5/1 percent confidence levels.

Table 9

Regression Results for Retail Trade

	Model 1	Model 2	Model 3	Model 4
Intercept	–0.0219	–0.0224	–0.0837**	–0.0830*
	(–1.142)	(–1.175)	(–2.054)	(–1.841)
sat104	0.0422	0.0532		0.0555
	(0.508)	(0.642)		(0.626)
sat1042	0.0110	–0.0004		–0.0039
	(0.151)	(–0.006)		(–0.050)
emp44_45_34		–0.1004	–0.1120	–0.0857
		(–1.467)	(–1.546)	(–1.198)
hwyaccess			–0.000229	–0.000274*
			(–1.434)	(–1.740)
bached00			0.2481*	0.1455
			(1.815)	(1.042)
unemp03			1.0414**	0.8562*
			(2.278)	(1.879)
rural			–0.0132	–0.0159
			(–0.953)	(–1.138)
R^2	0.072	0.090	0.089	0.144
Adjusted R^2	0.055	0.064	0.046	0.087
F-statistic	4.20**	3.55**	2.06*	2.50**
n	112	112	112	112

NOTE: Numbers in parentheses are *t*-statistics; */**/*** indicates significance at the 10/5/1 percent confidence levels.

Table 10

Regression Results for Transportation and Warehousing

	Model 1	Model 2	Model 3	Model 4
Intercept	–0.3130*	–0.3259**	0.0308	–0.0835
	(–1.926)	(–2.029)	(0.092)	(–0.210)
sat104	0.8014	0.9295		0.6747
	(1.141)	(1.334)		(0.590)
sat1042	–0.6466	–0.7395		–0.6035
	(–1.022)	(–1.180)		(–0.640)
emp48_49_34		–0.3339*	–0.3050*	–0.3205
		(–1.812)	(–1.675)	(–1.410)
hwyaccess			0.001524	0.001621
			(1.211)	(1.240)
bached00			–0.0999	–0.2570
			(–0.088)	(–0.250)
unemp03			–1.8209	–2.0990
			(–0.501)	(–0.500)
rural			–0.0893	–0.0673
			(–0.772)	(–0.460)
R^2	0.016	0.051	0.083	0.093
Adjusted R^2	–0.006	0.019	0.030	0.017
F-statistic	0.71	1.58	1.56	1.22
n	92	92	92	92

NOTE: Numbers in parentheses are *t*-statistics; */**/*** indicates significance at the 10/5/1 percent confidence levels.

Table 11

Regression Results for Information

	Model 1	Model 2	Model 3	Model 4
Intercept	–1.3904***	–1.3975***	–1.0817***	–1.5642***
	(–7.608)	(–7.705)	(–3.303)	(–4.150)
sat104	3.5404***	3.6109***		2.7246***
	(4.710)	(4.832)		(4.340)
sat1042	–2.6044***	–2.6591***		–2.0416***
	(–3.994)	(–4.103)		(–3.570)
emp51_34		0.2389	0.2120	0.2453**
		(1.510)	(1.291)	(2.110)
hwyaccess			0.000673	0.000492
			(0.538)	(0.630)
bached00			3.6844***	2.6651**
			(3.355)	(2.250)
unemp03			3.6022	1.9360
			(1.017)	(0.510)
rural			–0.1838	–0.1321
			(–1.480)	(–1.180)
R^2	0.266	0.286	0.291	0.420
Adjusted R^2	0.248	0.260	0.246	0.367
F-statistic	14.67***	10.70***	6.42***	7.87***
n	84	84	84	84

NOTE: Numbers in parentheses are *t*-statistics; */**/*** indicates significance at the 10/5/1 percent confidence levels.

Table 12

Regression Results for Finance and Insurance

	Model 1	Model 2	Model 3	Model 4
Intercept	0.0882*	0.0884*	0.1452	0.1593
	(1.916)	(1.936)	(1.505)	(1.553)
sat104	–0.1579	–0.1555		–0.1089
	(–0.790)	(–0.784)		(–0.510)
sat1042	0.0672	0.0694		0.0359
	(0.377)	(0.392)		(0.192)
emp52_34		–0.1429	–0.1546*	–0.1455
		(–1.645)	(–1.711)	(–1.604)
hwyaccess			0.000072	0.000142
			(0.191)	(0.372)
bached00			–0.3995	–0.2823
			(–1.252)	(–0.849)
unemp03			–0.9763	–0.8134
			(–0.912)	(–0.754)
rural			0.0055	0.0059
			(0.158)	(0.166)
R^2	0.032	0.058	0.050	0.068
Adjusted R^2	0.013	0.030	0.001	0.000
F-statistic	1.68	2.04	1.01	0.99
n	103	103	103	103

NOTE: Numbers in parentheses are *t*-statistics; */**/*** indicates significance at the 10/5/1 percent confidence levels.

Table 13

Regression Results for Real Estate and Rental and Leasing

	Model 1	Model 2	Model 3	Model 4
Intercept	–0.3452**	–0.2765*	–0.9924***	–1.1343***
	(–2.361)	(–1.878)	(–3.622)	(–2.790)
sat104	1.1267*	0.9297		0.8904
	(1.805)	(1.500)		(1.220)
sat1042	–0.8476	–0.6935		–0.7373
	(–1.525)	(–1.260)		(–1.220)
emp53_34		–0.2013**	–0.2511***	–0.2359**
		(–2.084)	(–2.679)	(–2.620)
hwyaccess			0.000231	0.000314
			(0.233)	(0.330)
bached00			2.4956***	2.2130**
			(2.869)	(2.370)
unemp03			8.4204***	7.7797*
			(2.716)	(1.980)
rural			0.1264	0.1536
			(1.375)	(1.340)
R^2	0.046	0.091	0.190	0.210
Adjusted R^2	0.024	0.060	0.142	0.143
F-statistic	2.11	2.91**	3.99***	3.14***
n	91	91	91	91

NOTE: Numbers in parentheses are *t*-statistics; */**/*** indicates significance at the 10/5/1 percent confidence levels.

Table 14

Regression Results for Professional, Scientific, and Technical Services

	Model 1	Model 2	Model 3	Model 4
Intercept	–0.4827***	–0.5022***	–0.9608***	–0.9995***
	(–3.043)	(–3.095)	(–3.444)	(–2.940)
sat104	0.9555	1.0098		0.0960
	(1.423)	(1.487)		(0.120)
sat1042	–0.7463	–0.7798		–0.1670
	(–1.283)	(–1.331)		(–0.240)
emp54_34		0.0487	0.0158	0.0107
		(0.610)	(0.215)	(0.050)
hwyaccess			0.002047*	0.002136
			(1.814)	(1.070)
bached00			2.5142***	2.6492***
			(2.660)	(2.820)
unemp03			5.7840*	6.1294*
			(1.865)	(1.830)
rural			–0.1020	–0.0926
			(–1.011)	(–0.790)
R^2	0.021	0.024	0.180	0.184
Adjusted R^2	0.002	–0.004	0.140	0.127
F-statistic	1.12	0.87	4.51***	3.24***
n	109	109	109	109

NOTE: Numbers in parentheses are *t*-statistics; */**/*** indicates significance at the 10/5/1 percent confidence levels.

Table 15

Regression Results for Management of Companies and Enterprises

	Model 1	Model 2	Model 3	Model 4
Intercept	1.0839**	0.9459**	2.5492***	2.6532***
	(2.426)	(2.135)	(3.864)	(3.922)
sat104	–3.2493*	–2.7434*		–1.1233
	(–2.043)	(–1.737)		(–0.756)
sat1042	2.2258*	1.8210		0.4818
	(1.735)	(1.430)		(0.403)
emp55_34		–0.5545	–0.2124	–0.1776
		(–1.553)	(–0.645)	(–0.555)
hwyaccess			0.000936	0.001203
			(0.766)	(0.945)
bached00			–3.4965**	–2.5110*
			(–2.503)	(–1.725)
unemp03			–32.8718***	–29.6529***
			(–4.087)	(–3.568)
rural			0.6480***	0.5375**
			(2.855)	(2.177)
R^2	0.204	0.279	0.517	0.590
Adjusted R^2	0.138	0.186	0.402	0.439
F-statistic	3.07*	2.97*	4.49***	3.91***
n	27	27	27	27

NOTE: Numbers in parentheses are t-statistics; */**/*** indicates significance at the 10/5/1 percent confidence levels.

Table 16

Regression Results for Administrative, Support, and Waste Management and Remediation Services

	Model 1	Model 2	Model 3	Model 4
Intercept	–0.8048***	–0.8225***	–0.9155*	–1.4892***
	(–3.749)	(–3.879)	(–1.938)	(–3.088)
sat104	3.3569***	3.5039***		3.0858***
	(3.648)	(3.843)		(3.095)
sat1042	–2.8518***	–2.9873***		–2.7935***
	(–3.492)	(–3.690)		(–3.220)
emp56_34		–0.2026*	–0.1189	–0.1433
		(–1.771)	(–0.956)	(–1.208)
hwyaccess			0.001013	0.001463
			(0.655)	(0.987)
bached00			2.6551*	2.3009
			(1.912)	(1.642)
unemp03			8.0518	6.8384
			(1.449)	(1.272)
rural			–0.1362	0.0212
			(–0.883)	(0.137)
R^2	0.145	0.178	0.124	0.232
Adjusted R^2	0.123	0.146	0.066	0.159
F-statistic	6.69***	5.62***	2.15*	3.19***
n	82	82	82	82

NOTE: Numbers in parentheses are *t*-statistics; */**/*** indicates significance at the 10/5/1 percent confidence levels.

Table 17

Regression Results for Educational Services

	Model 1	Model 2	Model 3	Model 4
Intercept	–1.2298**	–1.2218**	–0.3593	–1.7970
	(–2.429)	(–2.375)	(–0.457)	(–1.397)
sat104	3.4602*	3.4229*		3.4027
	(1.895)	(1.843)		(1.452)
sat1042	–2.6005*	–2.5801*		–2.7168
	(–1.822)	(–1.780)		(–1.479)
emp61_34		0.1311	0.1183	0.3076
		(0.236)	(0.193)	(0.484)
hwyaccess			0.001346	0.001518
			(0.732)	(0.791)
bached00			1.7215	2.4842
			(0.885)	(1.236)
unemp03			–4.1990	2.1853
			(–0.457)	(0.211)
rural			0.1120	0.2258
			(0.410)	(0.745)
R^2	0.095	0.096	0.126	0.186
Adjusted R^2	0.043	0.017	–0.011	–0.005
F-statistic	1.84	1.21	0.92	0.98
n	38	38	38	38

NOTE: Numbers in parentheses are *t*-statistics; */**/*** indicates significance at the 10/5/1 percent confidence levels.

Table 18

Regression Results for Health Care and Social Assistance

	Model 1	Model 2	Model 3	Model 4
Intercept	–0.0031	–0.0058	–0.0375	–0.0447
	(–0.158)	(–0.299)	(–0.981)	(–1.066)
sat104	0.0021	0.0107		0.0987
	(0.025)	(0.128)		(1.103)
sat1042	0.0364	0.0298		–0.0476
	(0.496)	(0.408)		(–0.614)
emp62_34		0.0775	0.0830	0.0963*
		(1.517)	(1.619)	(1.889)
hwyaccess			0.000108	0.000081
			(0.673)	(0.509)
bached00			0.1040	0.0091
			(0.776)	(0.066)
unemp03			0.1593	–0.0564
			(0.379)	(–0.133)
rural			0.0366**	0.0379***
			(2.594)	(2.635)
R^2	0.044	0.064	0.087	0.131
Adjusted R^2	0.027	0.039	0.045	0.075
F-statistic	2.60*	2.52*	2.07*	2.31**
n	115	115	115	115

NOTE: Numbers in parentheses are *t*-statistics; */**/*** indicates significance at the 10/5/1 percent confidence levels.

Table 19

Regression Results for Arts, Entertainment, and Recreation

	Model 1	Model 2	Model 3	Model 4
Intercept	–0.5365***	–0.5341***	–0.7935**	–0.9087***
	(–2.994)	(–3.042)	(–2.538)	(–2.713)
sat104	1.4161*	1.6032**		0.7610
	(1.985)	(2.268)		(1.030)
sat1042	–0.9953	–1.1892*		–0.6316
	(–1.609)	(–1.931)		(–0.990)
emp71_34		–0.4322*	–0.6026**	–0.6093**
		(–1.775)	(–2.612)	(–2.576)
hwyaccess			0.000458	0.000553
			(0.490)	(0.545)
bached00			2.2911***	2.1123**
			(2.692)	(2.385)
unemp03			6.4519*	5.5176
			(1.716)	(1.414)
rural			–0.1144	–0.078
			(–1.156)	(–0.732)
R^2	0.102	0.155	0.300	0.316
Adjusted R^2	0.068	0.105	0.229	0.214
F-statistic	2.97*	3.11**	4.20***	3.09***
n	55	55	55	55

NOTE: Numbers in parentheses are *t*-statistics; */**/*** indicates significance at the 10/5/1 percent confidence levels.

Table 20

Regression Results for Accomodations and Food Services

	Model 1	Model 2	Model 3	Model 4
Intercept	0.1260**	0.1399***	0.1066	0.1660
	(2.577)	(2.828)	(1.061)	(1.573)
sat104	–0.3120	–0.3599*		–0.3966*
	(–1.486)	(–1.706)		(–1.734)
sat1042	0.1969	0.2488		0.2826
	(1.052)	(1.315)		(1.401)
emp72_34		–0.1724	–0.1674	–0.1663
		(–1.505)	(–1.442)	(–1.421)
hwyaccess			–0.000028	0.000018
			(–0.071)	(0.045)
bached00			–0.3259	–0.1271
			(–0.986)	(–0.373)
unemp03			–0.1845	0.1745
			(–0.163)	(0.155)
rural			–0.0198	–0.0308
			(–0.554)	(–0.850)
R^2	0.048	0.070	0.034	0.078
Adjusted R^2	0.028	0.041	–0.017	0.008
F-statistic	2.45*	2.41*	0.66	1.11
n	100	100	100	100

NOTE: Numbers in parentheses are *t*-statistics; */**/*** indicates significance at the 10/5/1 percent confidence levels.

Table 21

Regression Results for Other Services (Except Public Administration)

	Model 1	Model 2	Model 3	Model 4
Intercept	–0.0988***	–0.0893**	0.0012	–0.0367
	(–2.706)	(–2.439)	(0.017)	(–0.493)
sat104	0.3207**	0.2834*		0.1758
	(2.061)	(1.820)		(1.106)
sat1042	–0.2999**	–0.2694*		–0.1954
	(–2.200)	(–1.977)		(–1.422)
emp81_34		–0.1242*	–0.1337*	–0.1251*
		(–1.712)	(–1.930)	(–1.798)
hwyaccess			0.000564**	0.000614**
			(2.018)	(2.200)
bached00			0.2168	0.2482
			(0.918)	(1.022)
unemp03			–1.2369	–1.1539
			(–1.565)	(–1.448)
rural			0.0059	0.0153
			(0.234)	(0.590)
R^2	0.045	0.071	0.162	0.191
Adjusted R^2	0.027	0.044	0.121	0.134
F-statistic	2.48*	2.66**	3.94***	3.37***
n	108	108	108	108

NOTE: Numbers in parentheses are *t*-statistics; */**/*** indicates significance at the 10/5/1 percent confidence levels.

Table 22

Regression Results for Unclassified

	Model 1	Model 2	Model 3	Model 4
Intercept	–1.5715	–1.4059	–0.9754	–1.6043
	(–2.105)	(–1.759)	(–1.762)	(–1.154)
sat104	1.9049	1.4702		1.6130
	(0.791)	(0.580)		(0.469)
sat1042	–1.1321	–0.8312		–1.0778
	(–0.640)	(–0.448)		(–0.428)
emp99_34		0.1637	0.2043	0.1596
		(0.661)	(0.823)	(0.577)
hwyaccess			0.000975	0.001018
			(0.875)	(0.716)
bached00			0.6187	0.5194
			(0.504)	(0.394)
unemp03			–0.3898	1.0663
			(–0.061)	(0.147)
rural			–0.0185	–0.0042
			(–0.107)	(–0.022)
R^2	0.109	0.133	0.182	0.204
Adjusted R^2	0.004	–0.030	–0.110	–0.260
F-statistic	1.04	0.82	0.62	0.44
n	20	20	20	20

NOTE: Numbers in parentheses are *t*-statistics; */**/*** indicates significance at the 10/5/1 percent confidence levels.

In the information sector, the analysis shows a substantial positive impact of broadband availability on employment growth, ranging from 25.27 to 87.07 percent. This growth is not surprising because this sector contains primarily information technology jobs housed by broadband providers, computer hardware and software related industries, and other technology companies that are the most likely to adopt and use broadband extensively. Additionally, jobs within the information sector are likely to allow or even promote working from home. At a residential level, increased broadband availability improves the ability of these employees to telecommute, which reduces a firm's administrative (including real estate) costs. This allows businesses to expand and hire more telecommuters without incurring the administrative costs of keeping an office.

In administrative, support, waste management and remediation services, broadband's contribution to employment growth ranges between 23.74 and 84.56 percent. This is another industry that provides likely opportunities for working from home, enabling reduced costs and potentially increased investment in labor. Additionally, this industry sector contains service industries such as call centers, which are highly dependent upon broadband. In recent years, several call centers have located or expanded in rural areas of Kentucky, but needed broadband service to do so.

Given that construction is a secondary industry, growth in construction depends on employment growth in other sectors. As other sectors grow, they demand additional facilities that create jobs in construction. In addition, economic growth often attracts new residents, which in turn increases the demand for residential construction. To the extent that we have already realized positive employment growth due to broadband in other industries, it is not surprising that broadband contributes to employment growth at rates between 0.62 and 21.76 percent in the construction industry in the 2004-05 period.

Broadband deployment also had a positive and significant impact on the mining industry. This result is also not surprising, because the industry relies heavily on broadband technology for many of its production and communication processes, including the transmission of market prices on which production decisions are made. However, given the small sample size in this sector we cannot generalize the result.

For some industries, namely, real estate, rental and leasing (Table 13), arts, entertainment and recreation (Table 19), and other services (Table 21), broadband is positive and significant in Model 1 but becomes insignificant when we add control variables. *F*-statistics indicate the overall significance of Model 4 in those industries, implying that the variables jointly explain employment growth. This suggests that broadband does contribute to employment growth, though the other variables are more influential to employment growth than broadband. Adding control variables in Model 4 overshadows the impact of broadband deployment on employment growth. Similarly for educational services (Table 17), broadband deployment is positive and significant in Models 1 and 2, but it becomes insignificant in Model 4. However, given the small sample size and Model 4 being insignificant, the results for educational services are inconclusive.

For an additional set of industries, there is weak evidence that broadband deployment affects employment growth. Broadband deployment has a positive sign but is not significant in any of the four models for the retail trade (Table 9), professional, scientific, and technical services (Table 14), and health care and social assistance (Table 18) sectors. Although the broadband parameters are statistically zero, the positive value does suggest nominal correlation between broadband deployment and employment growth in these industries. Additional evidence is found in the *F*-test for overall model significance: All of the models containing the broadband parameters are statistically significant. These results seem consistent with these industries, as they are sectors that consist chiefly of secondary industry jobs that are dependent on primary industries. Additionally, as has been documented elsewhere (see Varian et al., 2002), health care has been one of the slowest industries to adopt broadband and still has the lowest adoption rates of any sector. Without at least a propensity to adopt, it is understandable why broadband availability alone may not immediately affect job growth in this sector.

For the above mentioned industries, then, broadband infrastructure appears to lower costs and/or make markets more accessible, leading to employment growth. It should be noted that these industries are made up of primarily higher wage jobs, suggesting that broadband deployment encourages the growth of higher wage jobs.

The broadband impact is negative and significant for only one industry sector, accommodations and food services (Table 20). The results suggest that broadband deployment will decrease employment by 0.34 to 39.68 percent in this sector. One explanation for this finding could be that individuals are relying more on the Internet for information about travel destinations and hotel arrangements rather than working through related service providers, which may decrease employment within the travel agency industry. An additional and broader explanation is that broadband access increases worker productivity such that employment declines when firms adopt broadband technologies. Given the typically low wages of this industry (which could be indicative of low productivity), it is possible that broadband availability enables firms to substitute technology for labor.

Although broadband shows a negative impact for utilities (Table 5) and management of companies and enterprises (Table 15), sample sizes are very small for both of these industries, so the results are not representative across Kentucky counties and will not be considered further.

The industries where no variables are significant in any models, and none of the models is significant, are forestry, fishing, and hunting (Table 3), manufacturing (Table 7), finance and insurance (Table 12), and unclassified (Table 22). However, the sample sizes in forestry, fishing, and hunting and unclassified are too small to draw any conclusions. For manufacturing and finance and insurance, the insignificance of our control variables and models suggest that we have poor models. That is to say, our independent variables are not explaining the variance in employment growth between 2004 and 2005. Regression results for transportation and warehousing show only previous employment growth being significant with a negative sign (see Table 10). However, none of the models is significant according to the *F*-test, suggesting that broadband infrastructure has no statistical impact on employment growth for transportation and warehousing.

CONCLUSIONS

Based on the results above, we conclude that broadband deployment has a significant positive impact on a region's overall employment growth. Broadband infrastructure appears to reduce costs and/or increase market access, and thus lead to job creation and growth in total employment. At the sectoral level, broadband deployment positively impacts mining; construction; information; and administration, support, and waste management and remediation services. Broadband deployment does contribute to employment growth within real estate, rental, and leasing; arts, entertainment, and recreation; and other services; however, for these three sectors, other economic variables appear to be more influential to job growth than the availability of broadband. Weak evidence suggests that broadband availability may positively impact retail trade; professional, scientific, and technical services; and health care and social assistance, though the impact is likely to be indirect given the supporting nature of these industries to the economy. Broadband deployment appears to negatively impact accommodation and food services. These job losses, however, may be the result of substituting broadband technologies for less productive workers, which should lead to higher wages in the long run.

The results also suggest that broadband infrastructure contributes most to employment growth when counties are neither sparse nor saturated in their deployment. That is to say, employment growth seems to be highest around the mean level of saturation, and this result stems from the diminishing returns to scale of broadband infrastructure, manifested by the significant but negative saturation squared term. From a productivity perspective, this result captures the notion that a critical amount of broadband infrastructure may be needed to sizably increase employment, but once a community is completely built out (i.e., saturation rate equals 1), additional broadband infrastructure will not (indeed, cannot) further affect employment growth. The policy implication is that investment in broadband infrastructure achieves its greatest return, measured by employment growth, in communities that have average saturation levels. Additionally, policymakers may want to encourage investment in broadband in poor counties, which also tend to be rural and/or characterized by low-income households, so that they can benefit from the higher levels of employment generation.

Extensions to this research are threefold. First, we have assumed that all broadband infrastructures are equal; however, they are not. In the United States, broadband is typically characterized as having an upload or download speed greater than 200 kilobits per second. Many service providers greatly exceed this standard, though some do not. Ideally, one would want to differentiate the broadband infrastructure to identify the speed and/or platform that are most conducive to employment growth. Policymakers need such information to make wise choices about the kind of broadband infrastructure to deploy. Second, broadband availability and broadband adoption are two very different concepts; we would like to revise this study using measures of broadband adoption. Third, we want to use the broadband deployment and adoption data to examine their impacts on different demographics, such as the poor and the elderly.

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